Destructive Testing Procedures and Microsectioning Guidelines for Printed-Wiring Boards (PWBs)

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ABSTRACT: This document establishes destructive testing procedures and microsectioning guidelines for facilities involved in inspection/testing of printed-wiring boards (PWBs) in accordance with DEC STD 088-0 Qualification Procedure for All Printed-Wiring Board Suppliers.

APPLICABILITY: The requirements of this specification are mandatory for all Digital organizations that perform inspection/testing in accordance with DEC STD 088-0. The requirements also apply to any external facility performing destructive testing in accordance with DEC STD 088-0. These test procedures and guidelines shall be uniformly applied and administered on a worldwide basis.

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Responsible Department:	Material and Technology Analysis Laboratory
Responsible Person:	David Quaranta
SMC Writer:	Eric Falkof

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David Quaranta- Specification Owner

Direct requests for further information to:

David Quaranta or James Chiang
Use $ VTX ELF for the latest location information.

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1 PURPOSE

This document establishes the procedures and guidelines for facilities involved in inspection/testing of printed-wiring boards (PWBs) in accordance with *DEC STD 88-0 Qualification Procedure for All Printed-Wiring Board Suppliers*.

1.1 GOAL

The goal of this document is to provide facilities with a consistent method for inspection /testing and a guideline for microsectioning testing. These test procedures and guidelines shall be uniformily applied and administered on a worldwide basis.

1.2 APPLICABILITY

The requirements of this specification are mandatory for all Digital organizations that perform inspection/testing in accordance with DEC STD 088-0. The requirements also apply to any external facility performing destructive testing for Digital in accordance with DEC STD 088-0.

1.3 RESPONSIBILITY

The following are required to participate in the testing processes.

1. The Inspection/Test Facility shall:
   - — Be certified to perform inspection/testing in accordance with EL-MF088-03, *Laboratory Certification and Audit Procedures for Facilities that Inspect/Test Printed-Wiring Boards.*
   - — Be responsible for completing the testing processes and following the procedures as outlined in section 2.
2. The Certifying Agency shall oversee the testing procedure and recommended processes.

2 SAMPLE DESTRUCTIVE TEST PROCEDURE

1. The Certified Test facility shall:
   a. Select a minimum of three locations on the PWBs by starting at one corner of the board and working diagonally across the board. Refer to Figure 1 for an example.
   b. Sample two diagonal corners and the center of the PWB.
   c. Minimum:
      - Identify Layer 1 for tracking purposes on each sample for microsectioning.
      - Choose diagonal corner sites and label them A and C to represent the corners of the PWB.
      - Label the center section as B.

      NOTE

      Samples may be taken from all corners of the board. Additional sections may be used for further evaluation when deemed necessary by the Inspection/Test facility, or stated in the Qualification Plan. Refer to DEC STD 088-0 for more information.

   d. Cut and remove the samples. Refer to section 3.2 for procedure.

      NOTE

      An appropriate sample removal method should be used to ensure there is no mechanical damage (such as routing, or abrasive cutting). Do not punch-out samples.

   e. Identify samples from the various prescribed locations for the following evaluations.
      - Vertical microsectioning - As-received quality and dimensional verification. Refer to section 6 for procedure.
      - Thermal stress testing - Refer to *DEC STD 176-0 Printed-Wiring Board Acceptance Criteria* for procedure.
      - Horizontal Microsectioning for Registration Analysis - Refer to section 8 for procedure.

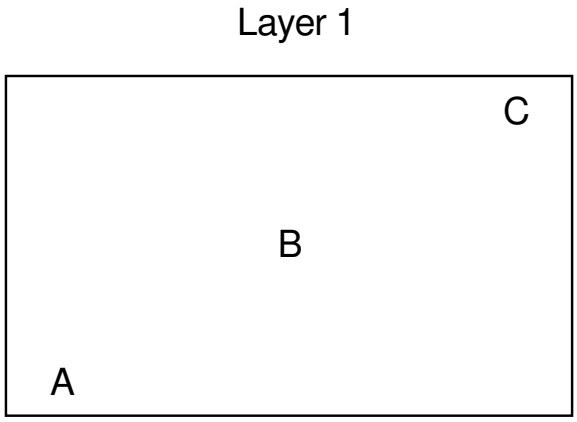
   f. Prepare microsections using the following methods on the as-received PWBs and thermal stress tested samples.
      — Pregrind the samples. Refer to section 4 for recommended procedures.
      — Epoxy sample mountings. Refer to section 5 for recommended procedure.
      — Grind the samples. Refer to section 6.1 for recommended procedure.
      — Polish the samples. Refer to section 6.2 for recommended procedure.
   g. Perform evaluation and analysis on samples for registration, as-received quality, thermal stress tested samples, and dimensional analysis.
2. Document the microsections in the form of photomicrographs (4X5 Polaroid).

3 SAMPLE DESIGNATION FOR DESTRUCTIVE TESTING

Microsectioning testing involves the preparation of a sample for metallographic (metallurgical) inspection. Microsectioning testing is a process inclusive of grinding, polishing, and chemically etching of PWBs samples.

Samples for microsectioning are taken from three locations on the PWB starting at any corner and working diagonally across the board. The intent is to sample two diagonal corners and the center of the PWB, as a minimum. Refer to Figure 1 for an example.

Figure 1: Microsectioning Sample Locations



3.1 IDENTIFICATION OF MICROSECTIONING SAMPLES

The following convention shall be used to identify microsections used in the qualification program.

```
lot number - board number - board section

     Example:  Region A from a PWB submitted as part
               of Lot #1 (Board #1 of 3) include the following identification
               on the microsection:

               1-1-A
               Designations should follow chronological sequence in
               terms of date code and serial number.
```

3.2 EXCISE SAMPLE FOR DESTRUCTIVE TESTING

Samples should be removed by one of the following methods.

a. Air or electric die grinder (high speed) with an abrasive cut-off wheel. (This is the preferred method.)

b. The use of high r/min and very light force for all cutting.

c. Routing.

d. Fine-tooth jewelers saw or liquid-cooled abrasive cutoff wheels.

3.2.1 Cutting Dimensions

When cutting the sample, a sufficient amount of material should be left around the area of interest to prevent sample preparation damage to the area being examined. The Plated Through Hole Pattern (PTH) of interest should be no closer than 0.25 inches to the edge of the cut sample.

Typical dimensions are 1.25 in. $\times$ 1.25 in. for as-received PWBs (vertical) and thermal stress samples, and 1 in. $\times$ 1 in. minimum for registration (horizontal) samples.

NOTE

If a fine-tooth jewelers saw is used, the sample size should be increased to lessen the chance of introducing defects into the area of interest (such as, delamination or laminate cracks). The PTH pattern should be approximately 0.5 inch from the cutting edge of the sample.

4 PREGRINDING PROCEDURE

To pregrind for vertical as-received PWBs and thermal stress samples, the following is recommended.

— Using 120 grit SIC paper with a 300 r/min wheel speed and a water flush, remove all sharp edges and remove enough material so that the sample will fit into the standard 1.5 in. mounting cup. Grind until the edge of the conductor pads of the PThs row of interest are reached.

— Ensure that the row of PTHs is parallel to the preground surface and that individual PTHs are ground along a parallel plane in the Z-axis.

— To pregrind for horizontal samples, use 120 grit SIC paper with a 300 r/min wheel speed and a water flush to remove all sharp edges. Grind away enough material to allow the sample to fit into the mounting cup.

NOTE

Grid size recommendations are based on U.S. measurement standards.

5 EPOXY SAMPLE MOUNTING PROCESS

The epoxy used for sample mounting should have the following characteristics.

— Low curing temperature

— Good edge retention (hard copy)

— Ability to flow

— Clear for viewing sample

Examples of epoxies which exhibit these properties are Mark V EZ Mount RR-32™ or Epofix Resin and Hardner™ .

NOTE

The proper mixture of resin/hardener is critical to ensure that excessive curing temperatures are not achieved.

™ Mark V EZ Mount is a trademark of Mark V Limited Corporation.

™ Epofix Reson and Hardner is a trademark of Steuers, Inc.

5.1 VACUUM MOUNTING PROCEDURE

Vacuum mounting is the recommended vacuum process. The entire process should not take more than one minute - longer exposure than a minute may result in poor mount quality. The following is the recommended procedure.

For Mark V EZ Mount RR-22:

1. Preheat resin at 100 degrees C for 20 minutes.
2. Add room temperature hardener and mix thoroughly.
3. Pour epoxy into mounting cups (with sample) and place mounted sample into vacuum bell jar.
4. Apply vacuum until bubbles form, then release vacuum and reapply vacuum to break bubbles.
5. Repeat until bubbles no longer form.
6. Allow sufficient time for proper curing of the epoxy.

NOTE

Preheating of the resin is not necessary, if the Dexter Hysol Epoxy Mounting system is used.

6 MICROSECTIONING GUIDELINE FOR PREPARING VERTICAL SAMPLES

The following is used for preparing vertical microsections for as-received quality evaluation, thermal stress test evaluation, and dimensional analysis.

6.1 GRINDING PROCEDURE

The following grinding procedure is recommended.

1. Using 240 grit SiC paper with a 300 r/min wheel speed and a water flush, grind through the conductor pads to the outer surface of the PTHs of interest. Ensure that the grinding is performed evenly so that Side 1 and Side 2 of the PTH lie along a parallel plane in the Z-axis, and that the row of holes are all ground evenly along the same plane.
2. Using 320 grit SiC paper with a 300 r/min wheel speed and a water flush, begin grinding into the plated copper, again ensuring that the PTHs are being kept along a parallel plane to the Z-axis and to the row of holes. Grind approximately 1/3 of the radius to the center of the PTHs of interest.
3. Using 400 grit SiC paper with a 150 r/min wheel speed and a water flush, continue grinding away approximately another 1/3 of the radius to the center of the PTHs of interest.
4. Using 600 grit SiC paper with a 150 r/min wheel speed and a water flush, continue grinding until the center of PTHs are reached.
5. Rotate samples 90 degrees between each step or SiC grit size.
6. Clean samples between each step or grit size by flushing thoroughly with water.

7. Apply force on the sample using less as finer grit sizes are used.

NOTE

Extra care should be taken when preparing smaller hole sizes. This is best accomplished using finer grit sizes (for example 400 or 600) to grind to the PTH center.

6.2 POLISHING SAMPLE PROCEDURE

To polish vertical microsections:

1. Using six micron diamond paste with a wheel speed of approximately 100 r/min with lubrication, polish with heavy hand pressure against the wheel rotation counting the number of turns (approximately 100 total) and rotate the sample 90 degrees every 20 turns.
2. Clean samples in isopropyl alcohol or propanol for ten minutes in an ultrasonic cleaner.
3. Using one micron diamond paste with a wheel speed of approximately 100 r/min with lubrication, polish with lighter hand pressure against the wheel rotation counting the number of turns (approximately 55 total) and rotate the sample 90 degrees every 20 turns.
4. Clean samples in isopropyl alcohol or propanol for 10 minutes in an ultrasonic cleaner.
5. Using Struer's OP-S 0.05 liquid or similar alumina compound (0.05 micron Al2O3) with a wheel speed of approximately 50 r/min, polish with light hand pressure against the wheel rotation, counting the number of turns (approximately 25 total). Keep the wheel wet as polishing is performed.
6. Swab sample with isopropyl alcohol or propanol and then clean for ten minutes in an ultrasonic cleaner.

NOTE

Recommended polishing cloths are Buehler TEXMET for the six and one micron diamond; and Buehler MICRCLOTH for the OP-S liquid.

6.3 SAMPLE ETCHING

After polishing, all samples should be etched for two to six seconds using the following mixture. For best results, the mixture should be freshly mixed.

- Five parts of 28% reagent grade NH_4OH (ammonium hydroxide)
- Five parts of DI H_20 (water)
- Two parts of 3% reagent grade H_2O_2 (hydrogen peroxide)

To perform sample etching:

1. Swab sample with a cotton swab that has been soaked in the etch.
2. Rinse sample immediately with tap water, and then clean in alcohol in an ultrasonic cleaner for approximately one minute.
3. Staining of the samples will occur if the samples are not properly cleaned or are left too long between final polish and etching.

6.4 THERMAL STRESS TESTING PROCEDURE

1. Refer to *DEC STD 176-1 Printed-Wiring Board Repair Criteria* for Thermal Stress Testing Procedures.
2. Use the microsectioning guidelines to prepare vertical samples for evaluation. Refer to section 6 for the process.

7 EVALUATION AND ANALYSIS

7.1 AS-RECEIVED EVALUATION

Perform visual evaluation on all as-received microsection samples by observing the following:

— Laminating material characteristics such as voids, blowholes, delamination, cracks, pink ring, and wicking.

— Inner and outerlayer copper foil characteristics such as grain structure, cracks, and defects.

— Electroless copper plating characteristics such as voids and interconnect bonding quality.

— Electrolytic copper plating characteristics such as voids and nodules.

— Inner layer/PTH interconnect characteristics such as separation, cracks, and voids.

— PTH characteristics such as outer pad configuration, hole wall pullaway, resin recession, outgasing, plating uniformity.

— Tin/lead solder characteristics such as microstructure and coverage.

— Each hole size in the board viewed with the magnification of approximately 50X.

— Any defects or nonconformance situations.

— Typical interconnection from each PWB lot. This should include a view of an interconnection from each hole size present in a given technology.

7.2 THERMAL STRESS EVALUATION

Perform visual evaluation for thermal stress (solderfloat) testing samples. Refer to DEC STD 176-0 for more information.

The following are criteria for thermal stress evaluation.

— PTH copper plating

— Plated interconnection integrity

— Laminate material integrity

The following are the procedures for thermal stress evaluation.

1. View each hole size in the board. The magnification for the view should be approximately 50X.
2. View any defects, nonconforming situations, or worst case observed situations of PTHs subjected to the thermal stress test, from the PWBs in a given lot.

3. View typical interconnection from each PWB lot, after thermal stress exposure, representative of those typically observed from that lot. This should include a view of an interconnection from each hole size present in a given technology.
4. View any defects, nonconforming situations, or worst case situations with regard to interconnection integrity and quality, after thermal stress exposure, from any of the PBWs quality criteria.

7.3 DIMENSIONAL ANALYSIS PROCEDURE

1. Perform dimensional analysis.
   - Laminate (dielectric) material thicknesses
   - Copper foil thickness
   - PTH copper plating thickness
   - Innerlayer line width (top and bottom)
   - Outerlayer electrolytic copper thickness
   - Tin/lead thickness at crest regions and coverage for PTHs, vias, and SMT pads, if available.
2. Include data sheets with the measured and recorded values for the dimensional values. These values should be obtained from at least one hole size per microsection and, if possible, differing hole sizes from the same microsection.

8 REGISTRATION ANALYSIS

The following are examined during Registration Analysis.

As-received PWB quality:

1. Examine for breakout.
2. Verify defects found in vertical microsectioning (such as laminate cracks, voids, resin recession, barrel cracking/separation).
3. Assess for:
   — Circumferential copper voiding
   — Foreign material, debris
   — Signal etch integrity
   — Haloing
   — Refer to section 5 for epoxy sample mounting procedure.

To grind horizontal microsections:

— Using 120 grit SiC paper with 300 r/min wheel speed and a water flush, grind through the dielectric (laminate) material to the oxide coating for the inner layer.

— Using 320 grit SiC with 300 r/min wheel speed and a water flush, grind into the conductor pad to expose the entire pad.

— Using 600 grit SiC paper with a 150 r/min wheel speed and a water flush, clean up the layer by eliminating scratches from the previous step.

— Visually examine a minimum of 10X magnification to verify the registration condition.

— Examine each layer of the horizontal microsections prepared from each lot. Check the registration of the drill hole to the pad at each layer at a number of PTHs or vias. Document, in the form of a data sheet, and verify whether it is acceptable or not at each layer.

— If a suspect registration situation is observed, continue the polishing process recommended in section 6.2 and the etching process in section 6.3 and document the registration condition.

— Include photographic documentation representative of a typical view from each hole size in a given PWB lot. Include any nonconforming situations or violations of the general specification.

9 PHOTOGRAPHIC AND DIMENSIONAL DOCUMENTATION

Documentation of the microsections in the form of photomicrographs (4×5 Polaroid) shall be submitted to illustrate PWB quality and should include the following.

1. As-received PWB quality:
   - — Overall macroview of Sides 1 and 2 of a PWB representing those being submitted for qualification.
   - — View of a PTH or via from each PWB lot, representative of those typically observed from that lot. This should include a view of each hole size present in the given technology such as 0.038, 0.020, 0.010 inches. Typical magnification for this view would be approximately 50X.
   - — View of any nonconformance situation observed PTHs or vias present in a given PWB lot. If no documentation illustrating nonconformance is submitted, then it is assumed that the typical view is representative of all situations examined in the microsections.
   - — View of a typical interconnection (inner layer to PTH) from each PWB lot, representative of those typically observed from that lot. This should include a typical interconnection from each hole size present in the given technology. Typical magnification for this view should be 400X.
   - — View of any defects, nonconforming or worst case observed situations, with regard to interconnection integrity and quality from any of the PWBs submitted in a given qualification lot. Magnification should range between 100X and 400X.
   - — View of any other defects or observations listed under the visual inspection category of the as-received PWB quality criteria. Magnification should range between 50X and 400X, and any additional magnification to clearly illustrate the item should be used.
2. Thermal stress testing
   - — View of a PTH and via from each lot, after exposure to the thermal stress test representative of those typically observed from that lot. This should include views of each hole size present in that technology. The magnification for the view should be approximately 50%.

— View of any defects, nonconformance or worst case observed situations, of the PTHs or vias subjected to the thermal stress test, from PWBs in a given lot. Magnification should range between 50X and 400X, depending on the situation being illustrated.

— View of a typical interconnection from each PWB lot, after thermal stress exposure, representative of those typically observed from that lot. This should include a view of an interconnection from each hole size present in a given technology.

— View of any defects, nonconforming or worst case situations, with regard to interconnection integrity and quality after thermal stress exposure from any of the PWBs in a given lot.

— View of any other defect types or observations listed under the visual inspection category of the as-received PWB quality criteria.

3. Registration analysis

— Registration should be examined layer by layer in each of the horizontal microsections prepared from each lot. Registration of the drill hole to the pad should be checked at each layer at a number of PTHs or vias. Documentation is required in the form of a data sheet, verifying whether registration is acceptable or not at each layer.

— Photographic documentation shall include a representative or a typical view from each hole size in a given PWB lot, and any nonconforming situations or violations of the general specification.

4. Dimensional analysis

— Data sheets with the measured and recorded values for the dimensional values should be included. These values should be obtained from at least one hole size per microsection, and if possible, differing hole size from the same microsection.

10 SAMPLE RETENTION

All microsections prepared from each PWB lot in the qualification process should be preserved and stored for a minimum period of five years for further or future inspection.

APPENDIX A REFERENCED DOCUMENTS

A.1 EL-Class Digital Documents

EL-Class Number	Document Title
EL-00088-00	*DEC STD 088-0 Qualification Procedure for All Printed-Wiring Board Suppliers*
EL-00176-00	*DEC STD 176-0 Printed-Wiring Board Acceptance Criteria*
EL-00176-01	*DEC STD 176-1 Printed-Wiring Board Repair Criteria*
EL-MF088-03	*Laboratory Certification and Audit Procedures for Facilities that Inspect/Test Printed-Wiring Boards (PWBs)*

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GLOSSARY

Area Qualification Office: A functional office within the U.S., GIA, and European PWB community responsible for the content of this document, as well as maintaining all documentation and files required by the implementation of this document. The Qualification Office shall serve in a consultant role for application, technical service, and training for those groups responsible for implementing the requirements of this document in their respective geographical areas.

calibrate: To standardize (as a measuring instrument) by determining the deviation from a standard so as to ascertain the proper correction factors.

Certifying Agency: The Certifying Agency is made up of some designated members of the DEC STD 088-0 committee. The Certifying Agency or representative shall audit the Inspection/Test Facility for compliance to this specification, resulting in the facility becoming certified per this specification.)

DEC STD 088 Committee: The committee is comprised of cross-functional representatives from Digital. The committee is responsible for the technical content and requirements of DEC STD 088-0.

dimensional test: Measurement of specific PWB features against the design value.

electrical test methods: Checking the electrical integrity of PWBs after final fabrication.

Inspection/Test Facility: Any location or facility that performs inspection or destructive testing as part of DEC STD 088-0.

Master Equipment List: A list of equipment utilized to perform inspection/test on PWBs.

microsectioning: Destructive analysis of PWB products using metallographic procedures and optical microscopy.

supplier: Any supplier, internal or external to Digital, contracted to fabricate PWBs for Digital.

thermal stress test: Refer to DEC STD 176-0, Appendix D for specific procedures.

VMI: Visual Mechanical (nondestructive testing) Inspection performed to ensure critical acceptance criteria as contained in DEC STD 176 are met.

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